

MC33201, MC33202, MC33204, NCV33201, NCV33202, NCV33204

Low Voltage, Rail-to-Rail Operational Amplifiers

The MC33201/2/4 family of operational amplifiers provide rail-to-rail operation on both the input and output. The inputs can be driven as high as 200 mV beyond the supply rails without phase reversal on the outputs, and the output can swing within 50 mV of each rail. This rail-to-rail operation enables the user to make full use of the supply voltage range available. It is designed to work at very low supply voltages (± 0.9 V) yet can operate with a supply of up to +12 V and ground. Output current boosting techniques provide a high output current capability while keeping the drain current of the amplifier to a minimum. Also, the combination of low noise and distortion with a high slew rate and drive capability make this an ideal amplifier for audio applications.

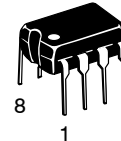
Features

- Low Voltage, Single Supply Operation (+1.8 V and Ground to +12 V and Ground)
- Input Voltage Range Includes both Supply Rails
- Output Voltage Swings within 50 mV of both Rails
- No Phase Reversal on the Output for Over-driven Input Signals
- High Output Current ($I_{SC} = 80$ mA, Typ)
- Low Supply Current ($I_D = 0.9$ mA, Typ)
- 600 Ω Output Drive Capability
- Extended Operating Temperature Ranges (-40° to $+105^\circ\text{C}$ and -55° to $+125^\circ\text{C}$)
- Typical Gain Bandwidth Product = 2.2 MHz
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- These Devices are Pb-Free and are RoHS Compliant



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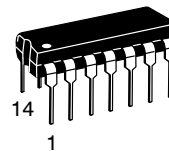
PDIP-8
P, VP SUFFIX
CASE 626



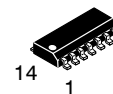
SOIC-8
D, VD SUFFIX
CASE 751



Micro8™
DM SUFFIX
CASE 846A



PDIP-14
P, VP SUFFIX
CASE 646



SOIC-14
D, VD SUFFIX
CASE 751A



TSSOP-14
DTB SUFFIX
CASE 948G

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 11 of this data sheet.

PIN CONNECTIONS

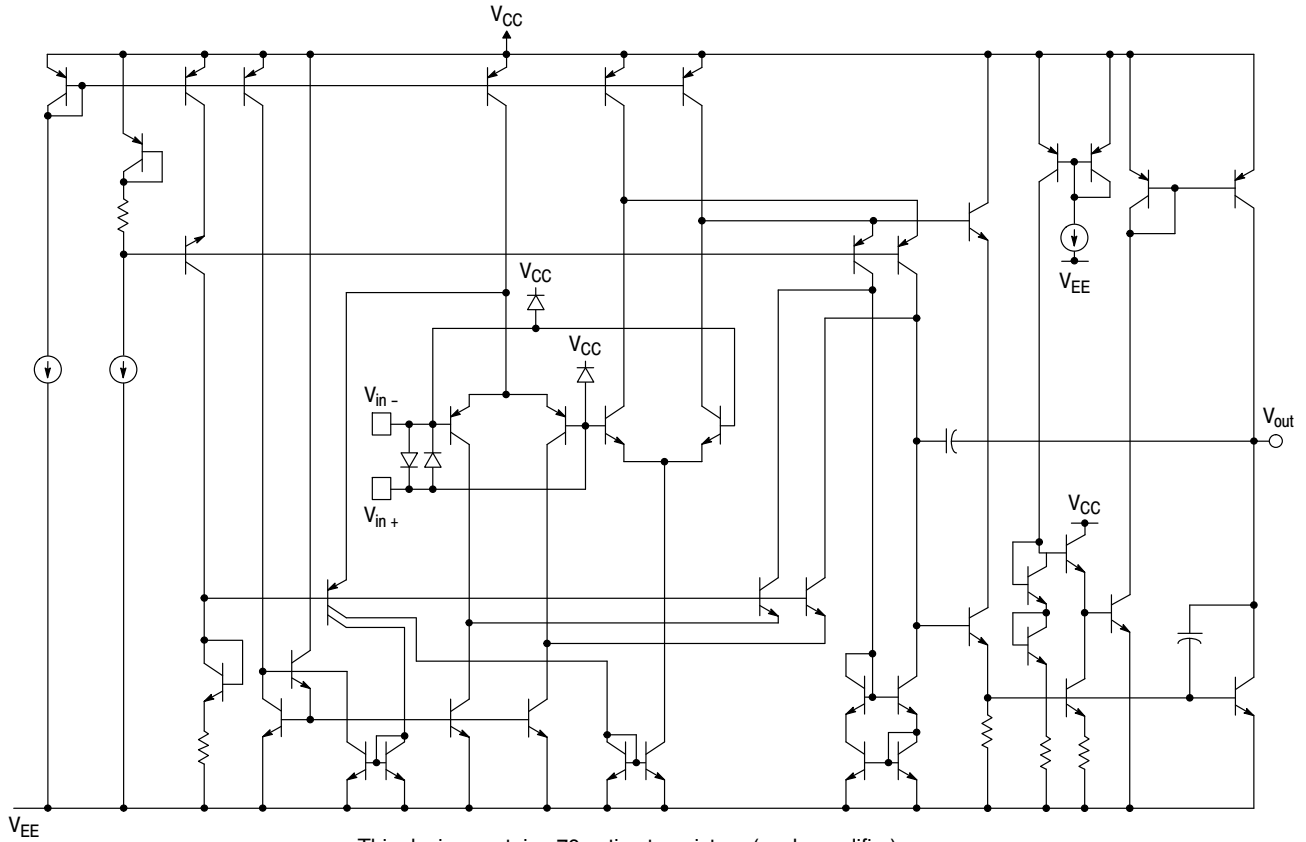
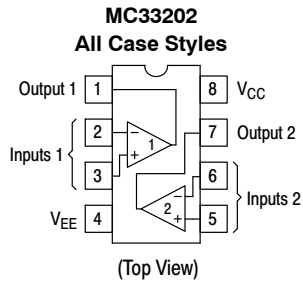
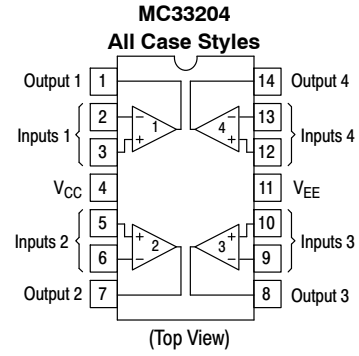
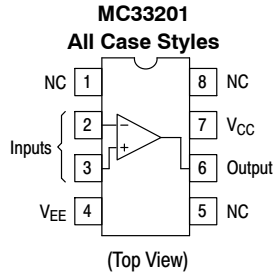


Figure 1. Circuit Schematic
(Each Amplifier)

MC33201, MC33202, MC33204, NCV33201, NCV33202, NCV33204

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage (V_{CC} to V_{EE})	V_S	+13	V
Input Differential Voltage Range	V_{IDR}	Note 1	V
Common Mode Input Voltage Range (Note 2)	V_{CM}	$V_{CC} + 0.5$ V to $V_{EE} - 0.5$ V	V
Output Short Circuit Duration	t_s	Note 3	sec
Maximum Junction Temperature	T_J	+150	°C
Storage Temperature	T_{stg}	- 65 to +150	°C
Maximum Power Dissipation	P_D	Note 3	mW

DC ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$)

Characteristic	$V_{CC} = 2.0$ V	$V_{CC} = 3.3$ V	$V_{CC} = 5.0$ V	Unit
Input Offset Voltage $V_{IO(max)}$ MC33201, NCV33201V MC33202, NCV33202, V MC33204, NCV33204, V	± 8.0 ± 10 ± 12	± 8.0 ± 10 ± 12	± 6.0 ± 8.0 ± 10	mV
Output Voltage Swing V_{OH} ($R_L = 10$ k Ω) V_{OL} ($R_L = 10$ k Ω)	1.9 0.10	3.15 0.15	4.85 0.15	V_{min} V_{max}
Power Supply Current per Amplifier (I_D)	1.125	1.125	1.125	mA

Specifications at $V_{CC} = 3.3$ V are guaranteed by the 2.0 V and 5.0 V tests. $V_{EE} = \text{GND}$.

DC ELECTRICAL CHARACTERISTICS ($V_{CC} = +5.0$ V, $V_{EE} = \text{Ground}$, $T_A = 25^\circ\text{C}$, unless otherwise noted.)

Characteristic	Figure	Symbol	Min	Typ	Max	Unit
Input Offset Voltage ($V_{CM} = 0$ V to 0.5 V, $V_{CM} = 1.0$ V to 5.0 V) MC33201/NCV33201V: $T_A = +25^\circ\text{C}$ MC33201: $T_A = -40^\circ$ to $+105^\circ\text{C}$ MC33201V/NCV33201V: $T_A = -55^\circ$ to $+125^\circ\text{C}$ MC33202/NCV33202, V: $T_A = +25^\circ\text{C}$ MC33202/NCV33202: $T_A = -40^\circ$ to $+105^\circ\text{C}$ MC33202V/NCV33202V: $T_A = -55^\circ$ to $+125^\circ\text{C}$ (Note 4) MC33204/NCV33204V: $T_A = +25^\circ\text{C}$ MC33204: $T_A = -40^\circ$ to $+105^\circ\text{C}$ MC33204V/NCV33204V: $T_A = -55^\circ$ to $+125^\circ\text{C}$ (Note 4)	3	$ V_{IO} $	- - - - - - - -	- - - - - - - -	6.0 9.0 13 8.0 11 14 10 13 17	mV
Input Offset Voltage Temperature Coefficient ($R_S = 50$ Ω) $T_A = -40^\circ$ to $+105^\circ\text{C}$ $T_A = -55^\circ$ to $+125^\circ\text{C}$	4	$\Delta V_{IO}/\Delta T$	- -	2.0 2.0	- -	$\mu\text{V}/^\circ\text{C}$
Input Bias Current ($V_{CM} = 0$ V to 0.5 V, $V_{CM} = 1.0$ V to 5.0 V) $T_A = +25^\circ\text{C}$ $T_A = -40^\circ$ to $+105^\circ\text{C}$ $T_A = -55^\circ$ to $+125^\circ\text{C}$	5, 6	$ I_{IB} $	- - -	80 100 -	200 250 500	nA

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

- The differential input voltage of each amplifier is limited by two internal parallel back-to-back diodes. For additional differential input voltage range, use current limiting resistors in series with the input pins.
- The input common mode voltage range is limited by internal diodes connected from the inputs to both supply rails. Therefore, the voltage on either input must not exceed either supply rail by more than 500 mV.
- Power dissipation must be considered to ensure maximum junction temperature (T_J) is not exceeded. (See Figure 2)
- All NCV devices are qualified for Automotive use.

MC33201, MC33202, MC33204, NCV33201, NCV33202, NCV33204

DC ELECTRICAL CHARACTERISTICS (cont.) ($V_{CC} = +5.0\text{ V}$, $V_{EE} = \text{Ground}$, $T_A = 25^\circ\text{C}$, unless otherwise noted.)

Characteristic	Figure	Symbol	Min	Typ	Max	Unit
Input Offset Current ($V_{CM} = 0\text{ V to } 0.5\text{ V}$, $V_{CM} = 1.0\text{ V to } 5.0\text{ V}$) $T_A = +25^\circ\text{C}$ $T_A = -40^\circ\text{ to } +105^\circ\text{C}$ $T_A = -55^\circ\text{ to } +125^\circ\text{C}$	–	$ I_{IO} $	–	5.0 10 –	50 100 200	nA
Common Mode Input Voltage Range	–	V_{ICR}	V_{EE}	–	V_{CC}	V
Large Signal Voltage Gain ($V_{CC} = +5.0\text{ V}$, $V_{EE} = -5.0\text{ V}$) $R_L = 10\text{ k}\Omega$ $R_L = 600\ \Omega$	7	A_{VOL}	50 25	300 250	– –	kV/V
Output Voltage Swing ($V_{ID} = \pm 0.2\text{ V}$) $R_L = 10\text{ k}\Omega$ $R_L = 10\text{ k}\Omega$ $R_L = 600\ \Omega$ $R_L = 600\ \Omega$	8, 9, 10	V_{OH} V_{OL} V_{OH} V_{OL}	4.85 – 4.75 –	4.95 0.05 4.85 0.15	– 0.15 – 0.25	V
Common Mode Rejection ($V_{in} = 0\text{ V to } 5.0\text{ V}$)	11	CMR	60	90	–	dB
Power Supply Rejection Ratio $V_{CC}/V_{EE} = 5.0\text{ V/GND to } 3.0\text{ V/GND}$	12	PSRR	500	25	–	$\mu\text{V/V}$
Output Short Circuit Current (Source and Sink)	13, 14	I_{SC}	50	80	–	mA
Power Supply Current per Amplifier ($V_O = 0\text{ V}$) $T_A = -40^\circ\text{ to } +105^\circ\text{C}$ $T_A = -55^\circ\text{ to } +125^\circ\text{C}$	15	I_D	– –	0.9 0.9	1.125 1.125	mA

AC ELECTRICAL CHARACTERISTICS ($V_{CC} = +5.0\text{ V}$, $V_{EE} = \text{Ground}$, $T_A = 25^\circ\text{C}$, unless otherwise noted.)

Characteristic	Figure	Symbol	Min	Typ	Max	Unit
Slew Rate ($V_S = \pm 2.5\text{ V}$, $V_O = -2.0\text{ V to } +2.0\text{ V}$, $R_L = 2.0\text{ k}\Omega$, $A_V = +1.0$)	16, 26	SR	0.5	1.0	–	V/ μs
Gain Bandwidth Product ($f = 100\text{ kHz}$)	17	GBW	–	2.2	–	MHz
Gain Margin ($R_L = 600\ \Omega$, $C_L = 0\text{ pF}$)	20, 21, 22	A_M	–	12	–	dB
Phase Margin ($R_L = 600\ \Omega$, $C_L = 0\text{ pF}$)	20, 21, 22	θ_M	–	65	–	Deg
Channel Separation ($f = 1.0\text{ Hz to } 20\text{ kHz}$, $A_V = 100$)	23	CS	–	90	–	dB
Power Bandwidth ($V_O = 4.0\text{ V}_{pp}$, $R_L = 600\ \Omega$, $\text{THD} \leq 1\%$)		BW_P	–	28	–	kHz
Total Harmonic Distortion ($R_L = 600\ \Omega$, $V_O = 1.0\text{ V}_{pp}$, $A_V = 1.0$) $f = 1.0\text{ kHz}$ $f = 10\text{ kHz}$	24	THD	– –	0.002 0.008	– –	%
Open Loop Output Impedance ($V_O = 0\text{ V}$, $f = 2.0\text{ MHz}$, $A_V = 10$)		$ Z_O $	–	100	–	Ω
Differential Input Resistance ($V_{CM} = 0\text{ V}$)		R_{in}	–	200	–	k Ω
Differential Input Capacitance ($V_{CM} = 0\text{ V}$)		C_{in}	–	8.0	–	pF
Equivalent Input Noise Voltage ($R_S = 100\ \Omega$) $f = 10\text{ Hz}$ $f = 1.0\text{ kHz}$	25	e_n	– –	25 20	– –	nV/ $\sqrt{\text{Hz}}$
Equivalent Input Noise Current $f = 10\text{ Hz}$ $f = 1.0\text{ kHz}$	25	i_n	– –	0.8 0.2	– –	pA/ $\sqrt{\text{Hz}}$



Figure 2. Maximum Power Dissipation versus Temperature



Figure 3. Input Offset Voltage Distribution



Figure 4. Input Offset Voltage Temperature Coefficient Distribution



Figure 5. Input Bias Current versus Temperature



Figure 6. Input Bias Current versus Common Mode Voltage

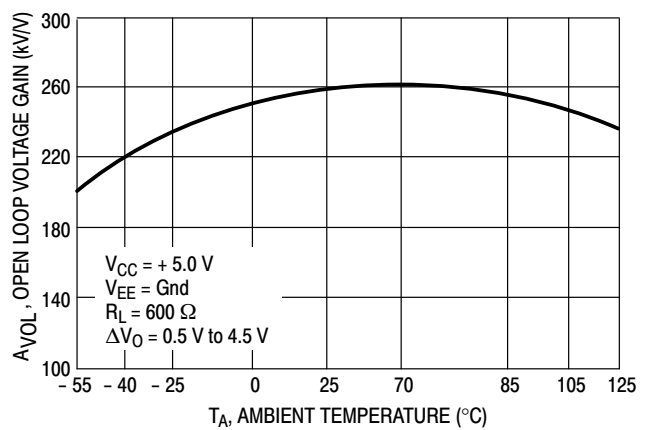


Figure 7. Open Loop Voltage Gain versus Temperature



Figure 8. Output Voltage Swing versus Supply Voltage



Figure 9. Output Saturation Voltage versus Load Current

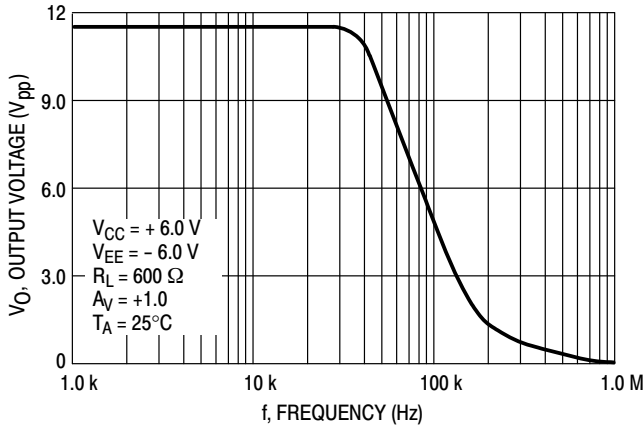


Figure 10. Output Voltage versus Frequency



Figure 11. Common Mode Rejection versus Frequency

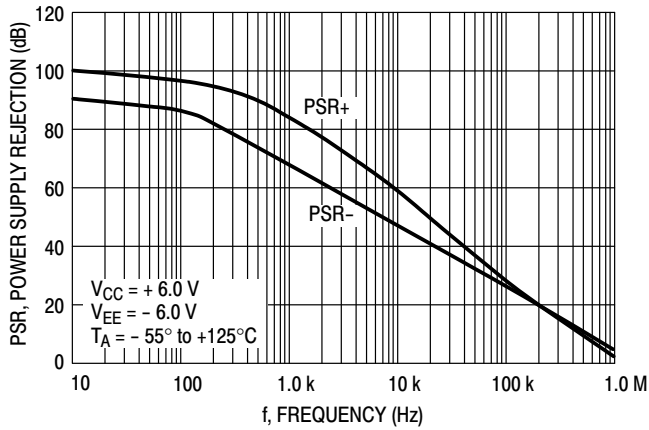


Figure 12. Power Supply Rejection versus Frequency

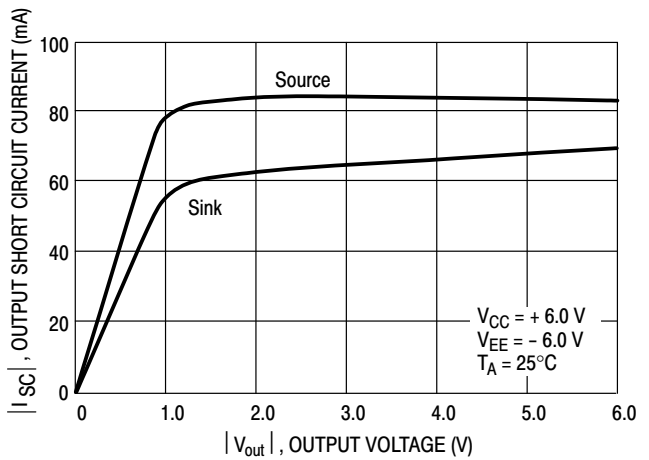


Figure 13. Output Short Circuit Current versus Output Voltage



Figure 14. Output Short Circuit Current versus Temperature



Figure 15. Supply Current per Amplifier versus Supply Voltage with No Load

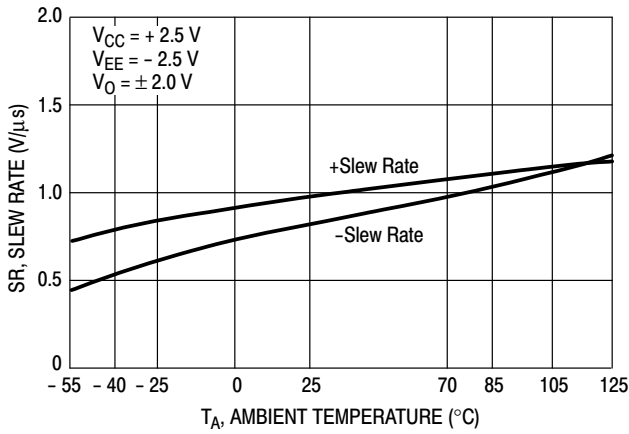


Figure 16. Slew Rate versus Temperature

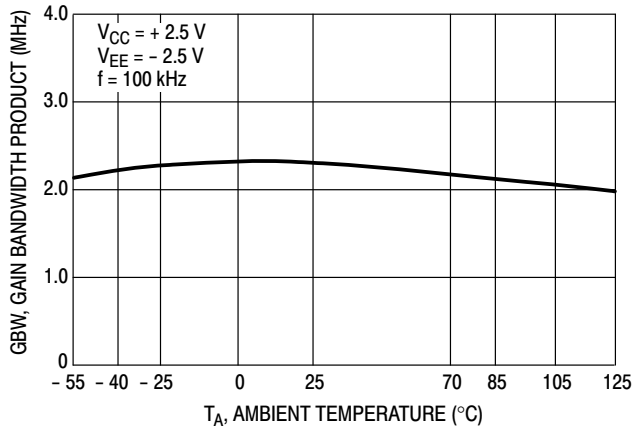


Figure 17. Gain Bandwidth Product versus Temperature



Figure 18. Voltage Gain and Phase versus Frequency



Figure 19. Voltage Gain and Phase versus Frequency



Figure 20. Gain and Phase Margin versus Temperature



Figure 21. Gain and Phase Margin versus Differential Source Resistance



Figure 22. Gain and Phase Margin versus Capacitive Load



Figure 23. Channel Separation versus Frequency



Figure 24. Total Harmonic Distortion versus Frequency



Figure 25. Equivalent Input Noise Voltage and Current versus Frequency

DETAILED OPERATING DESCRIPTION

General Information

The MC33201/2/4 family of operational amplifiers are unique in their ability to swing rail-to-rail on both the input and the output with a completely bipolar design. This offers low noise, high output current capability and a wide common mode input voltage range even with low supply voltages. Operation is guaranteed over an extended temperature range and at supply voltages of 2.0 V, 3.3 V and 5.0 V and ground.

Since the common mode input voltage range extends from V_{CC} to V_{EE} , it can be operated with either single or split voltage supplies. The MC33201/2/4 are guaranteed not to latch or phase reverse over the entire common mode range, however, the inputs should not be allowed to exceed maximum ratings.

Circuit Information

Rail-to-rail performance is achieved at the input of the amplifiers by using parallel NPN-PNP differential input stages. When the inputs are within 800 mV of the negative rail, the PNP stage is on. When the inputs are more than 800 mV greater than V_{EE} , the NPN stage is on. This switching of input pairs will cause a reversal of input bias currents (see Figure 6). Also, slight differences in offset voltage may be noted between the NPN and PNP pairs. Cross-coupling techniques have been used to keep this change to a minimum.

In addition to its rail-to-rail performance, the output stage is current boosted to provide 80 mA of output current, enabling the op amp to drive 600 Ω loads. Because of this high output current capability, care should be taken not to exceed the 150°C maximum junction temperature.

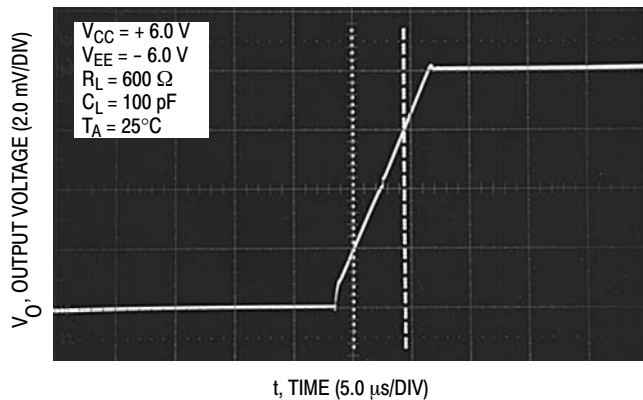


Figure 26. Noninverting Amplifier Slew Rate

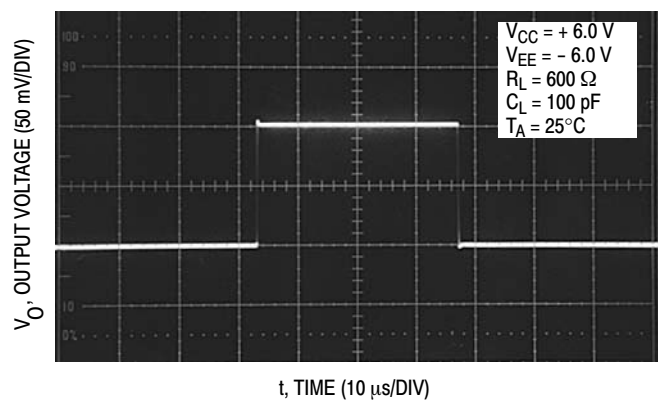


Figure 27. Small Signal Transient Response

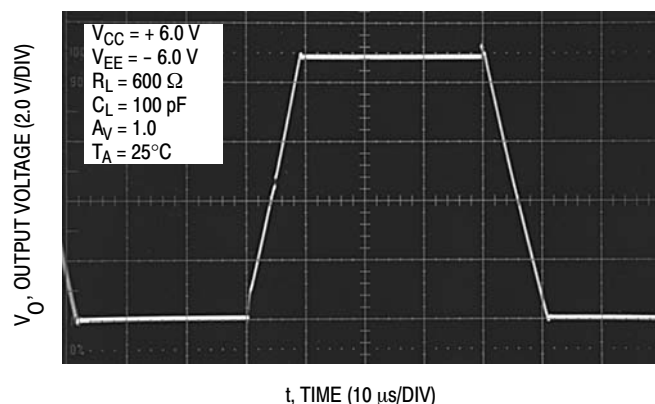


Figure 28. Large Signal Transient Response

Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to ensure proper solder connection interface

between the board and the package. With the correct pad geometry, the packages will self-align when subjected to a solder reflow process.

ORDERING INFORMATION

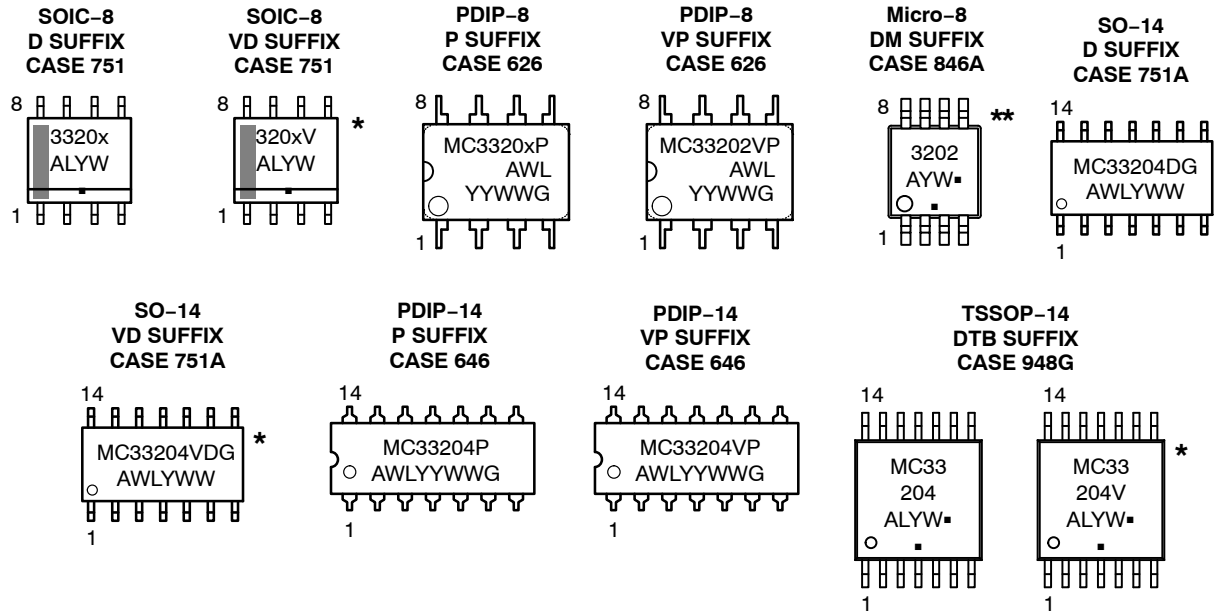
Operational Amplifier Function	Device	Operating Temperature Range	Package	Shipping†
Single	MC33201DG	$T_A = -40^\circ$ to $+105^\circ\text{C}$	SOIC-8 (Pb-Free)	98 Units / Rail
	MC33201DR2G			2500 / Tape & Reel
	MC33201VDG	$T_A = -55^\circ$ to 125°C		98 Units / Rail
	MC33201VDR2G			2500 / Tape & Reel
	NCV33201VDR2G			2500 / Tape & Reel
Dual	MC33202DG	$T_A = -40^\circ$ to $+105^\circ\text{C}$	SOIC-8 (Pb-Free)	98 Units / Rail
	MC33202DR2G			2500 / Tape & Reel
	MC33202DMR2G		Micro-8 (Pb-Free)	4000 / Tape & Reel
	NCV33202DMR2G*			
	MC33202VDG	$T_A = -55^\circ$ to 125°C	SOIC-8 (Pb-Free)	98 Units / Rail
	MC33202VDR2G			2500 / Tape & Reel
	NCV33202VDR2G*			
Quad	MC33204DG	$T_A = -40^\circ$ to $+105^\circ\text{C}$	SO-14 (Pb-Free)	55 Units / Rail
	MC33204DR2G			2500 Units / Tape & Reel
	MC33204DTBG		TSSOP-14 (Pb-Free)	96 Units / Rail
	MC33204DTBR2G			2500 Units / Tape & Reel
	MC33204VDG	$T_A = -55^\circ$ to 125°C	SO-14 (Pb-Free)	55 Units / Rail
	MC33204VDR2G			2500 Units / Tape & Reel
	NCV33204DR2G*		TSSOP-14 (Pb-Free)	
	NCV33204DTBR2G*			

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

*NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable.

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MARKING DIAGRAMS



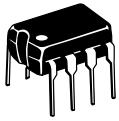
x = 1 or 2
 A = Assembly Location
 WL, L = Wafer Lot
 YY, Y = Year
 WW, W = Work Week
 G = Pb-Free Package
 ▪ = Pb-Free Package
 (Note: Microdot may be in either location)

*This marking diagram applies to NCV3320xV

**This marking diagram applies to NCV33202DMR2G

MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

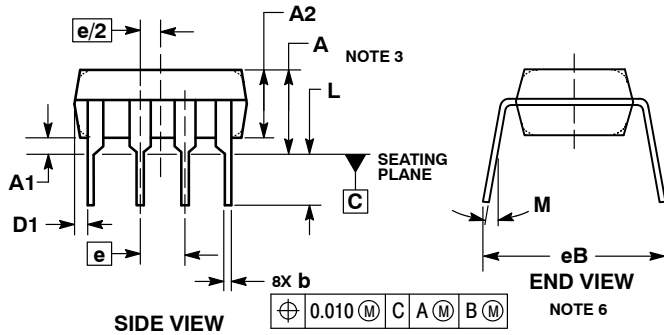
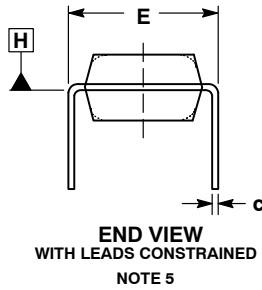
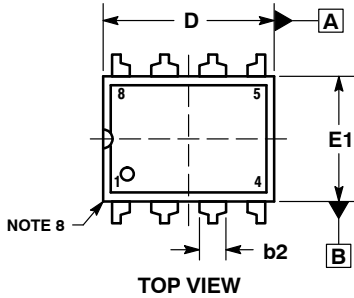
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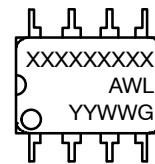


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSIONS A, A1 AND L ARE MEASURED WITH THE PACKAGE SEATED IN JEDEC SEATING PLANE GAUGE GS-3.
4. DIMENSIONS D, D1 AND E1 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS ARE NOT TO EXCEED 0.10 INCH.
5. DIMENSION E IS MEASURED AT A POINT 0.015 BELOW DATUM PLANE H WITH THE LEADS CONSTRAINED PERPENDICULAR TO DATUM C.
6. DIMENSION eB IS MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.
7. DATUM PLANE H IS COINCIDENT WITH THE BOTTOM OF THE LEADS, WHERE THE LEADS EXIT THE BODY.
8. PACKAGE CONTOUR IS OPTIONAL (ROUNDED OR SQUARE CORNERS).

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	----	0.210	----	5.33
A1	0.015	----	0.38	----
A2	0.115	0.195	2.92	4.95
b	0.014	0.022	0.35	0.56
b2	0.060 TYP		1.52 TYP	
C	0.008	0.014	0.20	0.36
D	0.355	0.400	9.02	10.16
D1	0.005	----	0.13	----
E	0.300	0.325	7.62	8.26
E1	0.240	0.280	6.10	7.11
e	0.100 BSC		2.54 BSC	
eB	----	0.430	----	10.92
L	0.115	0.150	2.92	3.81
M	----	10°	----	10°

GENERIC
MARKING DIAGRAM*



- XXXX = Specific Device Code
- A = Assembly Location
- WL = Wafer Lot
- YY = Year
- WW = Work Week
- G = Pb-Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present.

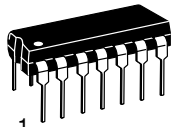
- STYLE 1:
PIN 1. AC IN
2. DC + IN
3. DC - IN
4. AC IN
5. GROUND
6. OUTPUT
7. AUXILIARY
8. V_{CC}

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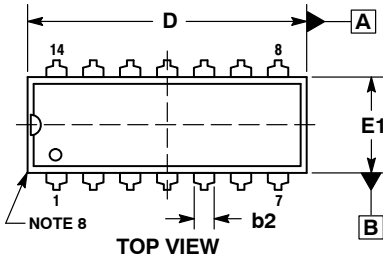
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MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

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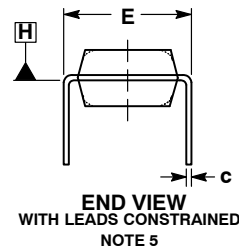


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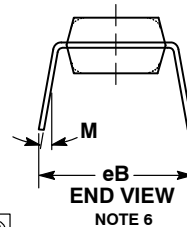
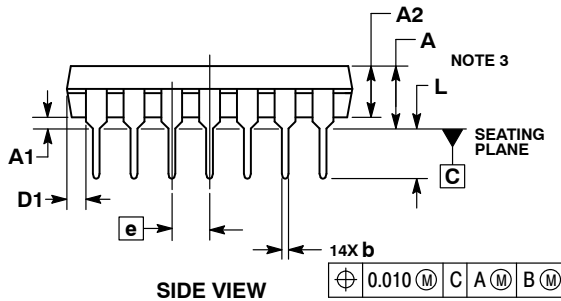
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ISSUE S

DATE 22 APR 2015



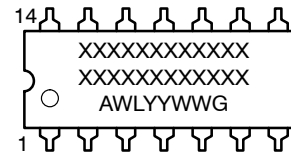
NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSIONS A, A1 AND L ARE MEASURED WITH THE PACKAGE SEATED IN JEDEC SEATING PLANE GAUGE GS-3.
4. DIMENSIONS D, D1 AND E1 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS ARE NOT TO EXCEED 0.10 INCH.
5. DIMENSION E IS MEASURED AT A POINT 0.015 BELOW DATUM PLANE H WITH THE LEADS CONSTRAINED PERPENDICULAR TO DATUM C.
6. DIMENSION eB IS MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.
7. DATUM PLANE H IS COINCIDENT WITH THE BOTTOM OF THE LEADS, WHERE THE LEADS EXIT THE BODY.
8. PACKAGE CONTOUR IS OPTIONAL (ROUNDED OR SQUARE CORNERS).



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	----	0.210	----	5.33
A1	0.015	----	0.38	----
A2	0.115	0.195	2.92	4.95
b	0.014	0.022	0.35	0.56
b2	0.060 TYP		1.52 TYP	
C	0.008	0.014	0.20	0.36
D	0.735	0.775	18.67	19.69
D1	0.005	----	0.13	----
E	0.300	0.325	7.62	8.26
E1	0.240	0.280	6.10	7.11
e	0.100 BSC		2.54 BSC	
eB	----	0.430	----	10.92
L	0.115	0.150	2.92	3.81
M	----	10°	----	10°

GENERIC
MARKING DIAGRAM*



- XXXXX = Specific Device Code
- A = Assembly Location
- WL = Wafer Lot
- YY = Year
- WW = Work Week
- G = Pb-Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present.

STYLES ON PAGE 2

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PDIP-14
CASE 646-06
ISSUE S

DATE 22 APR 2015

STYLE 1:
 PIN 1. COLLECTOR
 2. BASE
 3. EMITTER
 4. NO
CONNECTION
 5. EMITTER
 6. BASE
 7. COLLECTOR
 8. COLLECTOR
 9. BASE
 10. EMITTER
 11. NO
CONNECTION
 12. EMITTER
 13. BASE
 14. COLLECTOR

STYLE 2:
 CANCELLED

STYLE 3:
 CANCELLED

STYLE 4:
 PIN 1. DRAIN
 2. SOURCE
 3. GATE
 4. NO
CONNECTION
 5. GATE
 6. SOURCE
 7. DRAIN
 8. DRAIN
 9. SOURCE
 10. GATE
 11. NO
CONNECTION
 12. GATE
 13. SOURCE
 14. DRAIN

STYLE 5:
 PIN 1. GATE
 2. DRAIN
 3. SOURCE
 4. NO CONNECTION
 5. SOURCE
 6. DRAIN
 7. GATE
 8. GATE
 9. DRAIN
 10. SOURCE
 11. NO CONNECTION
 12. SOURCE
 13. DRAIN
 14. GATE

STYLE 6:
 PIN 1. COMMON CATHODE
 2. ANODE/CATHODE
 3. ANODE/CATHODE
 4. NO CONNECTION
 5. ANODE/CATHODE
 6. NO CONNECTION
 7. ANODE/CATHODE
 8. ANODE/CATHODE
 9. ANODE/CATHODE
 10. NO CONNECTION
 11. ANODE/CATHODE
 12. ANODE/CATHODE
 13. NO CONNECTION
 14. COMMON ANODE

STYLE 7:
 PIN 1. NO CONNECTION
 2. ANODE
 3. ANODE
 4. NO CONNECTION
 5. ANODE
 6. NO CONNECTION
 7. ANODE
 8. ANODE
 9. ANODE
 10. NO CONNECTION
 11. ANODE
 12. ANODE
 13. NO CONNECTION
 14. COMMON
 CATHODE

STYLE 8:
 PIN 1. NO CONNECTION
 2. CATHODE
 3. CATHODE
 4. NO CONNECTION
 5. CATHODE
 6. NO CONNECTION
 7. CATHODE
 8. CATHODE
 9. CATHODE
 10. NO CONNECTION
 11. CATHODE
 12. CATHODE
 13. NO CONNECTION
 14. COMMON ANODE

STYLE 9:
 PIN 1. COMMON CATHODE
 2. ANODE/CATHODE
 3. ANODE/CATHODE
 4. NO CONNECTION
 5. ANODE/CATHODE
 6. ANODE/CATHODE
 7. COMMON ANODE
 8. COMMON ANODE
 9. ANODE/CATHODE
 10. ANODE/CATHODE
 11. NO CONNECTION
 12. ANODE/CATHODE
 13. ANODE/CATHODE
 14. COMMON CATHODE

STYLE 10:
 PIN 1. COMMON
 CATHODE
 2. ANODE/CATHODE
 3. ANODE/CATHODE
 4. ANODE/CATHODE
 5. ANODE/CATHODE
 6. NO CONNECTION
 7. COMMON ANODE
 8. COMMON
 CATHODE
 9. ANODE/CATHODE
 10. ANODE/CATHODE
 11. ANODE/CATHODE
 12. ANODE/CATHODE
 13. NO CONNECTION
 14. COMMON ANODE

STYLE 11:
 PIN 1. CATHODE
 2. CATHODE
 3. CATHODE
 4. CATHODE
 5. CATHODE
 6. CATHODE
 7. CATHODE
 8. ANODE
 9. ANODE
 10. ANODE
 11. ANODE
 12. ANODE
 13. ANODE
 14. ANODE

STYLE 12:
 PIN 1. COMMON CATHODE
 2. COMMON ANODE
 3. ANODE/CATHODE
 4. ANODE/CATHODE
 5. ANODE/CATHODE
 6. COMMON ANODE
 7. COMMON CATHODE
 8. ANODE/CATHODE
 9. ANODE/CATHODE
 10. ANODE/CATHODE
 11. ANODE/CATHODE
 12. ANODE/CATHODE
 13. ANODE/CATHODE
 14. ANODE/CATHODE

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MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

ON Semiconductor®



SCALE 1:1

SOIC-8 NB
CASE 751-07
ISSUE AK

DATE 16 FEB 2011



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
 2. CONTROLLING DIMENSION: MILLIMETER.
 3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
 4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
 5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
 6. 751-01 THRU 751-06 ARE OBSOLETE. NEW STANDARD IS 751-07.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0°	8°	0°	8°
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

SOLDERING FOOTPRINT*



*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

GENERIC MARKING DIAGRAM*



XXXXXX = Specific Device Code
 A = Assembly Location
 L = Wafer Lot
 Y = Year
 W = Work Week
 ■ = Pb-Free Package

XXXXXX = Specific Device Code
 A = Assembly Location
 Y = Year
 WW = Work Week
 ■ = Pb-Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

STYLES ON PAGE 2

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SOIC-8 NB
CASE 751-07
ISSUE AK

DATE 16 FEB 2011

- | | | | |
|--|---|---|---|
| <p>STYLE 1:
 PIN 1. EMITTER
 2. COLLECTOR
 3. COLLECTOR
 4. EMITTER
 5. EMITTER
 6. BASE
 7. BASE
 8. EMITTER</p> | <p>STYLE 2:
 PIN 1. COLLECTOR, DIE, #1
 2. COLLECTOR, #1
 3. COLLECTOR, #2
 4. COLLECTOR, #2
 5. BASE, #2
 6. EMITTER, #2
 7. BASE, #1
 8. EMITTER, #1</p> | <p>STYLE 3:
 PIN 1. DRAIN, DIE #1
 2. DRAIN, #1
 3. DRAIN, #2
 4. DRAIN, #2
 5. GATE, #2
 6. SOURCE, #2
 7. GATE, #1
 8. SOURCE, #1</p> | <p>STYLE 4:
 PIN 1. ANODE
 2. ANODE
 3. ANODE
 4. ANODE
 5. ANODE
 6. ANODE
 7. ANODE
 8. COMMON CATHODE</p> |
| <p>STYLE 5:
 PIN 1. DRAIN
 2. DRAIN
 3. DRAIN
 4. DRAIN
 5. GATE
 6. GATE
 7. SOURCE
 8. SOURCE</p> | <p>STYLE 6:
 PIN 1. SOURCE
 2. DRAIN
 3. DRAIN
 4. SOURCE
 5. SOURCE
 6. GATE
 7. GATE
 8. SOURCE</p> | <p>STYLE 7:
 PIN 1. INPUT
 2. EXTERNAL BYPASS
 3. THIRD STAGE SOURCE
 4. GROUND
 5. DRAIN
 6. GATE 3
 7. SECOND STAGE Vd
 8. FIRST STAGE Vd</p> | <p>STYLE 8:
 PIN 1. COLLECTOR, DIE #1
 2. BASE, #1
 3. BASE, #2
 4. COLLECTOR, #2
 5. COLLECTOR, #2
 6. EMITTER, #2
 7. EMITTER, #1
 8. COLLECTOR, #1</p> |
| <p>STYLE 9:
 PIN 1. EMITTER, COMMON
 2. COLLECTOR, DIE #1
 3. COLLECTOR, DIE #2
 4. EMITTER, COMMON
 5. EMITTER, COMMON
 6. BASE, DIE #2
 7. BASE, DIE #1
 8. EMITTER, COMMON</p> | <p>STYLE 10:
 PIN 1. GROUND
 2. BIAS 1
 3. OUTPUT
 4. GROUND
 5. GROUND
 6. BIAS 2
 7. INPUT
 8. GROUND</p> | <p>STYLE 11:
 PIN 1. SOURCE 1
 2. GATE 1
 3. SOURCE 2
 4. GATE 2
 5. DRAIN 2
 6. DRAIN 2
 7. DRAIN 1
 8. DRAIN 1</p> | <p>STYLE 12:
 PIN 1. SOURCE
 2. SOURCE
 3. SOURCE
 4. GATE
 5. DRAIN
 6. DRAIN
 7. DRAIN
 8. DRAIN</p> |
| <p>STYLE 13:
 PIN 1. N.C.
 2. SOURCE
 3. SOURCE
 4. GATE
 5. DRAIN
 6. DRAIN
 7. DRAIN
 8. DRAIN</p> | <p>STYLE 14:
 PIN 1. N-SOURCE
 2. N-GATE
 3. P-SOURCE
 4. P-GATE
 5. P-DRAIN
 6. P-DRAIN
 7. N-DRAIN
 8. N-DRAIN</p> | <p>STYLE 15:
 PIN 1. ANODE 1
 2. ANODE 1
 3. ANODE 1
 4. ANODE 1
 5. CATHODE, COMMON
 6. CATHODE, COMMON
 7. CATHODE, COMMON
 8. CATHODE, COMMON</p> | <p>STYLE 16:
 PIN 1. EMITTER, DIE #1
 2. BASE, DIE #1
 3. EMITTER, DIE #2
 4. BASE, DIE #2
 5. COLLECTOR, DIE #2
 6. COLLECTOR, DIE #2
 7. COLLECTOR, DIE #1
 8. COLLECTOR, DIE #1</p> |
| <p>STYLE 17:
 PIN 1. VCC
 2. V2OUT
 3. V1OUT
 4. TXE
 5. RXE
 6. VEE
 7. GND
 8. ACC</p> | <p>STYLE 18:
 PIN 1. ANODE
 2. ANODE
 3. SOURCE
 4. GATE
 5. DRAIN
 6. DRAIN
 7. CATHODE
 8. CATHODE</p> | <p>STYLE 19:
 PIN 1. SOURCE 1
 2. GATE 1
 3. SOURCE 2
 4. GATE 2
 5. DRAIN 2
 6. MIRROR 2
 7. DRAIN 1
 8. MIRROR 1</p> | <p>STYLE 20:
 PIN 1. SOURCE (N)
 2. GATE (N)
 3. SOURCE (P)
 4. GATE (P)
 5. DRAIN
 6. DRAIN
 7. DRAIN
 8. DRAIN</p> |
| <p>STYLE 21:
 PIN 1. CATHODE 1
 2. CATHODE 2
 3. CATHODE 3
 4. CATHODE 4
 5. CATHODE 5
 6. COMMON ANODE
 7. COMMON ANODE
 8. CATHODE 6</p> | <p>STYLE 22:
 PIN 1. I/O LINE 1
 2. COMMON CATHODE/VCC
 3. COMMON CATHODE/VCC
 4. I/O LINE 3
 5. COMMON ANODE/GND
 6. I/O LINE 4
 7. I/O LINE 5
 8. COMMON ANODE/GND</p> | <p>STYLE 23:
 PIN 1. LINE 1 IN
 2. COMMON ANODE/GND
 3. COMMON ANODE/GND
 4. LINE 2 IN
 5. LINE 2 OUT
 6. COMMON ANODE/GND
 7. COMMON ANODE/GND
 8. LINE 1 OUT</p> | <p>STYLE 24:
 PIN 1. BASE
 2. EMITTER
 3. COLLECTOR/ANODE
 4. COLLECTOR/ANODE
 5. CATHODE
 6. CATHODE
 7. COLLECTOR/ANODE
 8. COLLECTOR/ANODE</p> |
| <p>STYLE 25:
 PIN 1. VIN
 2. N/C
 3. REXT
 4. GND
 5. IOUT
 6. IOUT
 7. IOUT
 8. IOUT</p> | <p>STYLE 26:
 PIN 1. GND
 2. dv/dt
 3. ENABLE
 4. ILIMIT
 5. SOURCE
 6. SOURCE
 7. SOURCE
 8. VCC</p> | <p>STYLE 27:
 PIN 1. ILIMIT
 2. OVLO
 3. UVLO
 4. INPUT+
 5. SOURCE
 6. SOURCE
 7. SOURCE
 8. DRAIN</p> | <p>STYLE 28:
 PIN 1. SW_TO_GND
 2. DASIC OFF
 3. DASIC_SW_DET
 4. GND
 5. V_MON
 6. VBULK
 7. VBULK
 8. VIN</p> |
| <p>STYLE 29:
 PIN 1. BASE, DIE #1
 2. EMITTER, #1
 3. BASE, #2
 4. EMITTER, #2
 5. COLLECTOR, #2
 6. COLLECTOR, #2
 7. COLLECTOR, #1
 8. COLLECTOR, #1</p> | <p>STYLE 30:
 PIN 1. DRAIN 1
 2. DRAIN 1
 3. GATE 2
 4. SOURCE 2
 5. SOURCE 1/DRAIN 2
 6. SOURCE 1/DRAIN 2
 7. SOURCE 1/DRAIN 2
 8. GATE 1</p> | | |

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MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

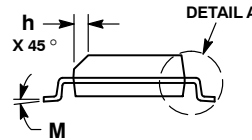
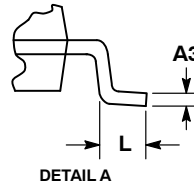
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SCALE 1:1

SOIC-14 NB
CASE 751A-03
ISSUE L

DATE 03 FEB 2016



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
 2. CONTROLLING DIMENSION: MILLIMETERS.
 3. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE PROTRUSION SHALL BE 0.13 TOTAL IN EXCESS OF AT MAXIMUM MATERIAL CONDITION.
 4. DIMENSIONS D AND E DO NOT INCLUDE MOLD PROTRUSIONS.
 5. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.054	0.068
A1	0.10	0.25	0.004	0.010
A3	0.19	0.25	0.008	0.010
b	0.35	0.49	0.014	0.019
D	8.55	8.75	0.337	0.344
E	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
H	5.80	6.20	0.228	0.244
h	0.25	0.50	0.010	0.019
L	0.40	1.25	0.016	0.049
M	0°	7°	0°	7°

SOLDERING FOOTPRINT*



DIMENSIONS: MILLIMETERS

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

GENERIC MARKING DIAGRAM*



- XXXXXX = Specific Device Code
- A = Assembly Location
- WL = Wafer Lot
- Y = Year
- WW = Work Week
- G = Pb-Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present.

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SOIC-14
CASE 751A-03
ISSUE L

DATE 03 FEB 2016

STYLE 1:
 PIN 1. COMMON CATHODE
 2. ANODE/CATHODE
 3. ANODE/CATHODE
 4. NO CONNECTION
 5. ANODE/CATHODE
 6. NO CONNECTION
 7. ANODE/CATHODE
 8. ANODE/CATHODE
 9. ANODE/CATHODE
 10. NO CONNECTION
 11. ANODE/CATHODE
 12. ANODE/CATHODE
 13. NO CONNECTION
 14. COMMON ANODE

STYLE 2:
 CANCELLED

STYLE 3:
 PIN 1. NO CONNECTION
 2. ANODE
 3. ANODE
 4. NO CONNECTION
 5. ANODE
 6. NO CONNECTION
 7. ANODE
 8. ANODE
 9. ANODE
 10. NO CONNECTION
 11. ANODE
 12. ANODE
 13. NO CONNECTION
 14. COMMON CATHODE

STYLE 4:
 PIN 1. NO CONNECTION
 2. CATHODE
 3. CATHODE
 4. NO CONNECTION
 5. CATHODE
 6. NO CONNECTION
 7. CATHODE
 8. CATHODE
 9. CATHODE
 10. NO CONNECTION
 11. CATHODE
 12. CATHODE
 13. NO CONNECTION
 14. COMMON ANODE

STYLE 5:
 PIN 1. COMMON CATHODE
 2. ANODE/CATHODE
 3. ANODE/CATHODE
 4. ANODE/CATHODE
 5. ANODE/CATHODE
 6. NO CONNECTION
 7. COMMON ANODE
 8. COMMON CATHODE
 9. ANODE/CATHODE
 10. ANODE/CATHODE
 11. ANODE/CATHODE
 12. ANODE/CATHODE
 13. NO CONNECTION
 14. COMMON ANODE

STYLE 6:
 PIN 1. CATHODE
 2. CATHODE
 3. CATHODE
 4. CATHODE
 5. CATHODE
 6. CATHODE
 7. CATHODE
 8. ANODE
 9. ANODE
 10. ANODE
 11. ANODE
 12. ANODE
 13. ANODE
 14. ANODE

STYLE 7:
 PIN 1. ANODE/CATHODE
 2. COMMON ANODE
 3. COMMON CATHODE
 4. ANODE/CATHODE
 5. ANODE/CATHODE
 6. ANODE/CATHODE
 7. ANODE/CATHODE
 8. ANODE/CATHODE
 9. ANODE/CATHODE
 10. ANODE/CATHODE
 11. COMMON CATHODE
 12. COMMON ANODE
 13. ANODE/CATHODE
 14. ANODE/CATHODE

STYLE 8:
 PIN 1. COMMON CATHODE
 2. ANODE/CATHODE
 3. ANODE/CATHODE
 4. NO CONNECTION
 5. ANODE/CATHODE
 6. ANODE/CATHODE
 7. COMMON ANODE
 8. COMMON ANODE
 9. ANODE/CATHODE
 10. ANODE/CATHODE
 11. NO CONNECTION
 12. ANODE/CATHODE
 13. ANODE/CATHODE
 14. COMMON CATHODE

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MECHANICAL CASE OUTLINE

PACKAGE DIMENSIONS

ON Semiconductor®



SCALE 2:1

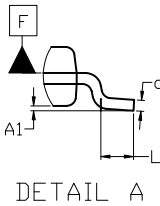
Micro8 CASE 846A-02 ISSUE K

DATE 16 JUL 2020



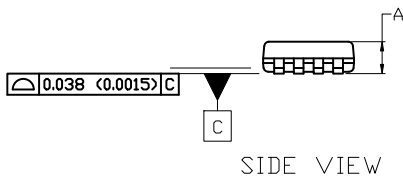
TOP VIEW

NOTE 3

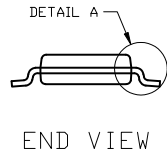


DETAIL A

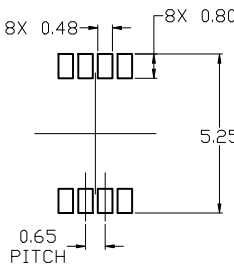
$\phi 0.08$ (0.003) M C B S A S



SIDE VIEW



END VIEW



RECOMMENDED MOUNTING FOOTPRINT

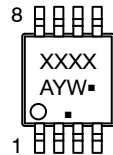
For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERM/D.

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION *b* DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE PROTRUSION SHALL BE 0.10 mm IN EXCESS OF MAXIMUM MATERIAL CONDITION.
4. DIMENSIONS *D* AND *E* DO NOT INCLUDE MOLD FLASH, PROTRUSION OR GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.15 mm PER SIDE. DIMENSION *E* DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 mm PER SIDE. DIMENSIONS *D* AND *E* ARE DETERMINED AT DATUM *F*.
5. DATUMS *A* AND *B* ARE TO BE DETERMINED AT DATUM *F*.
6. *A1* IS DEFINED AS THE VERTICAL DISTANCE FROM THE SEATING PLANE TO THE LOWEST POINT ON THE PACKAGE BODY.

DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	---	---	1.10
A1	0.05	0.08	0.15
<i>b</i>	0.25	0.33	0.40
<i>c</i>	0.13	0.18	0.23
<i>D</i>	2.90	3.00	3.10
<i>E</i>	2.90	3.00	3.10
<i>e</i>	0.65 BSC		
<i>H_E</i>	4.75	4.90	5.05
<i>L</i>	0.40	0.55	0.70

GENERIC MARKING DIAGRAM*



- XXXX = Specific Device Code
- A = Assembly Location
- Y = Year
- W = Work Week
- = Pb-Free Package

(Note: Microdot may be in either location)

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

STYLE 1:

1. SOURCE
2. SOURCE
3. SOURCE
4. GATE
5. DRAIN
6. DRAIN
7. DRAIN
8. DRAIN

STYLE 2:

1. SOURCE 1
2. GATE 1
3. SOURCE 2
4. GATE 2
5. DRAIN 2
6. DRAIN 2
7. DRAIN 1
8. DRAIN 1

STYLE 3:

1. N-SOURCE
2. N-GATE
3. P-SOURCE
4. P-GATE
5. P-DRAIN
6. P-DRAIN
7. N-DRAIN
8. N-DRAIN

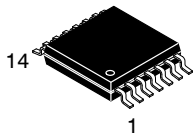
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DESCRIPTION:	MICRO8	PAGE 1 OF 1

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MECHANICAL CASE OUTLINE

PACKAGE DIMENSIONS

ON Semiconductor®



TSSOP-14 WB
CASE 948G
ISSUE C

DATE 17 FEB 2016

SCALE 2:1

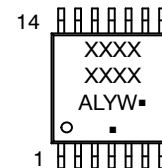


NOTES:

- DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
- CONTROLLING DIMENSION: MILLIMETER.
- DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
- DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
- DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
- TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
- DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE -W-.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.90	5.10	0.193	0.200
B	4.30	4.50	0.169	0.177
C	---	1.20	---	0.047
D	0.05	0.15	0.002	0.006
F	0.50	0.75	0.020	0.030
G	0.65 BSC		0.026 BSC	
H	0.50	0.60	0.020	0.024
J	0.09	0.20	0.004	0.008
J1	0.09	0.16	0.004	0.006
K	0.19	0.30	0.007	0.012
K1	0.19	0.25	0.007	0.010
L	6.40 BSC		0.252 BSC	
M	0°	8°	0°	8°

GENERIC MARKING DIAGRAM*

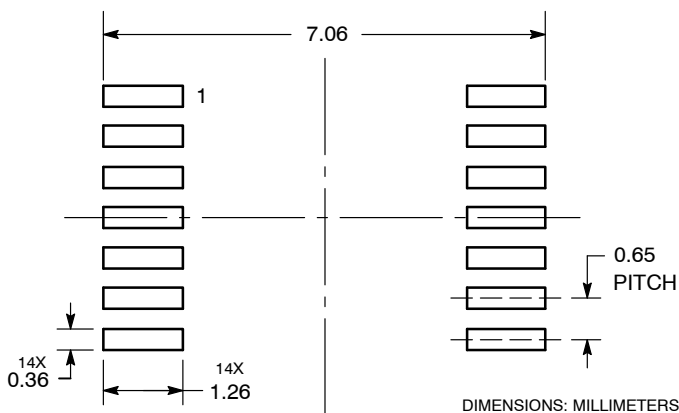


- A = Assembly Location
- L = Wafer Lot
- Y = Year
- W = Work Week
- = Pb-Free Package

(Note: Microdot may be in either location)

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present.

SOLDERING FOOTPRINT



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DESCRIPTION:	TSSOP-14 WB	PAGE 1 OF 1

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